

310
OCT 8 1988

83-B-5

A 13.80: INT-58

United States
Department of
Agriculture

Forest Service

Intermountain
Research Station

Resource Bulletin
INT-58

October 1988



Logging Utilization— Arizona, 1985

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RESEARCH SUMMARY

A study in 1985 on timber harvesting operations in Arizona resulted in estimates of logging residue, noninventory product volume, and removals associated with harvesting. Results show: factors that can be applied to product volumes to estimate removals, noninventory product volume, logging residue from product trees, and logging residue from non-product trees; the number and volume of trees by diameter at breast height class removed from growing-stock inventories per thousand cubic feet of product volume; the volume of residue in pieces 6 feet and longer to a 4-inch top as a proportion of product volume; and board-foot/cubic-foot conversion factors. This report also covers survey methods and data reliability.

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INTRODUCTION

The Forest Survey Unit of the Intermountain Research Station inventoried the non-National Forest lands in Arizona in 1984 and 1985 to estimate and describe the volume, growth, and mortality of the forests' trees. Timber product output (McLain 1988b), fuelwood harvest (McLain 1988a), and logging utilization studies were conducted concurrently with that inventory. The first two studies, timber product output and fuelwood harvest, provided estimates of log volumes harvested and delivered to primary wood processors (such as sawmills and house log plants) and residences burning wood. The logging utilization study provided the factors to convert these harvest estimates to estimates of removals associated with harvesting. These removals estimates, when compared to inventory volumes and growth, are used to estimate the residual inventory and rate of inventory change associated with harvesting. The factors themselves provide a means to analyze the components of removals and, when compared to those developed in previous years, to ascertain changes in logging utilization practices.

This bulletin reports the results of the logging utilization study conducted in Arizona, its use, and the study methods. The report presents factors to apply to harvest estimates to obtain estimates of removals, logging residue, diameter class distribution of the harvest, and the volume of residue in pieces 6 feet and longer.

The bulletin illustrates the factor formulas and the application of the factors and presents the derived estimates of logging residue, noninventory product volume, and removals associated with the 1984 timber harvest in Arizona.

Cubic-foot/board-foot conversions for both International 1/4-inch and Scribner rules are also included.

STUDY METHODS

The study was conducted in Arizona using the sampling and measurement techniques designed by A. K. Wilson of the Forest Survey Project at the Intermountain Station in 1959-60.

Sample Size and Distribution

Measurements were obtained on active sawlog and multiproduct logging operations, located on timberland, visited in the summer of 1985. These operations—the basic sample units—were distributed throughout the State and were selected within four strata defined by land ownership and operator size class. Two ownership classes were used—National Forest and other. Operator size class corresponded to the production class of the wood processing plant receiving the logs harvested. Two size classes were used—small (less than 10 MM board feet per year) and large (10 MM board feet and more per year).

Sample size was calculated to achieve a standard error of the logging residue ratio (total net cubic foot volume of logging residue divided by the total net volume of timber products) of not more than ± 20 percent.

The samples were distributed throughout the strata in proportion to the estimated harvest volume occurring in each stratum. It was estimated that measurements from 20 logging operations would provide sufficient sample data to achieve a standard error of the ratio of within 20 percent. Further, it was estimated that "large" mills (those with capacities of at least 10 MM board feet per year) received about 95 percent of the timber production and that 65 percent of the harvest occurred on National Forests. Twenty samples were distributed as close to these estimates as possible. The field crews actually measured 21 logging operations. Their measurements were at 20 logging operations sending logs to "large" mills and 14 logging operations occurring on National Forest lands (table 1).

Table 1—Number of logging operations measured in each stratum, Arizona, 1985

Stratum	Owner group		Total
	National Forest	Other	
----- <i>Number of operations measured</i> -----			
Mill size:			
Small	1	—	1
Large	13	7	20
Total	14	7	21

Data Collection

The study design prescribed four basic measurements to be obtained from each sample unit to meet the primary objectives of computing removals and logging residue factors.

On each sample unit 14 to 30 (average, 19) felled and bucked product trees, with an average sample unit total of about 10,000 board feet (International 1/4-inch rule) gross volume, and a varying number of associated nonproduct trees were measured to obtain the following:

1. Product volume
2. Noninventory volume in products
3. Volume of logging residue from product trees
4. Volume of logging residue from nonproduct trees

All measured trees were categorized as poletimber, sawtimber, (salvable) dead, cull, or nontimber. Both gross (includes defect) and net volumes in cubic feet and board feet (International 1/4-inch rule and Scribner rule) were obtained by scaling. These measurements were related to obtain factors (proportions) to apply to reported product volumes received by primary wood processors. Thus, all factors were calculated as proportions of product volume. No product volume from dead trees, cull trees, or nontimber species was encountered on the logging operations measured.

Factor Formulas

$$\text{Logging residue factor} = \frac{\text{product tree residue volume}}{\text{live product volume} + \frac{\text{nonproduct tree residue volume}}{\text{live + dead product volume}^1}}$$

$$\text{Product tree residue factor} = \frac{\text{product tree residue volume}}{\text{live product volume}}$$

$$\text{Nonproduct tree residue factor} = \frac{\text{nonproduct tree residue volume}}{\text{live + dead product volume}}$$

$$\text{Noninventory product volume factor} = \frac{\text{noninventory product volume}}{\text{live product volume}}$$

¹All 404 product trees measured on the 21 logging operations in the Arizona sample were live (green) trees. No product volume from salvable dead trees was encountered. Because, in this case, dead product volume equals zero, the denominators of all the factors could read "live product volume" or merely "product volume."

$$\text{Inventory product volume factor} = \frac{\text{inventory product volume}}{\text{live product volume}}$$

or

$$\text{Inventory product volume factor} = 1 - \text{noninventory product volume factor}$$

$$\text{Removals factor} = \frac{\text{live product volume} - \text{noninventory product volume} + \text{product tree residue volume}}{\text{live product volume}}$$

$$+ \frac{\text{nonproduct tree residue volume}}{\text{live + dead product volume}}$$

STUDY RESULTS

The factors presented in table 2 were used to derive the growing-stock and sawtimber removals estimates presented in table 3.

Sawlog, Pulpwood, and Other Industrial Estimates

Primary wood processors provided annual estimates of the total sawlog and other industrial timber product volumes received at their plants (McLain 1988b) and estimates of the proportion of that volume cut from dead trees. The volume from dead trees, exhibited in the "Salvable dead" column of table 3, was subtracted from the timber product volume. The appropriate factors in table 2 were applied to the remainder ("Live" column, table 3) to obtain the estimates of product volume from growing

Table 2—Logging residue, noninventory product volume, and removals factors in cubic and board feet, Arizona, 1985

Type of factor	Cubic feet	b.f.s. ¹	b.f.f. ²
Logging residue	0.071	0.024	0.025
Product tree residue	.055	.021	.022
Nonproduct tree residue	.016	.002	.003
Noninventory product volume	—	—	—
Inventory product volume	1	1	1
Growing-stock (cubic) or sawtimber (bd ft) removals	1.071	1.024	1.025

¹Board feet, Scribner rule.

²Board feet, International 1/4-inch rule.

stock and sawtimber, the product volume from noninventory material in product trees (which in Arizona was zero), and the growing-stock and sawtimber volumes left as logging residue (product tree residue and nonproduct tree residue resulting from the harvest of live product trees).

Additionally, the nonproduct tree residue factor was applied to the salvable dead product volumes to obtain the growing-stock and sawtimber volumes of nonproduct trees destroyed and killed while logging the salvable dead trees.

Fuelwood Estimates

Because the logging utilization data were not collected from fuelwood harvesting operations, some adjustments were made to estimate removals from growing stock and sawtimber associated with fuelwood harvesting. Noninventory product volume factors were applied to fuelwood live product estimates, but logging residue factors were not. An assumption was that all the growing-stock volume in trees cut for fuelwood and in trees killed by such

Table 3—Timber production and timber removals by source of material and product, Arizona, 1984

Products and additional removals	Product volume ¹				Noninventory ³ product volume	Growing-stock removals
	Total	Live	Salvable dead	Other ² sources		
<i>M cubic feet</i> -----						
Sawlogs	56,316	54,233	2,083	—	—	54,233
Pulpwood	7,110	7,106	4	—	—	7,106
Other industrial	185	185	—	—	—	185
Total	63,611	61,524	2,087	—	—	61,524
Fuelwood ⁴	18,180	856	3,965	13,359	—	856
Logging residue	—	—	—	—	—	4,401
Total	81,791	62,380	6,052	13,359	—	66,781
<i>M board feet (Scribner)</i> -----						
Sawlogs	336,593	324,150	12,443	—	—	324,150
Pulpwood	45,279	45,256	23	—	—	45,256
Other industrial	802	802	—	—	—	802
Total	382,674	370,208	12,466	—	—	370,208
Fuelwood ⁴	29,105	5,168	23,937	—	—	5,168
Logging residue	—	—	—	—	—	8,910
Total	411,779	375,376	36,403	— ²	—	384,286
<i>M board feet (International 1/4-inch)</i> -----						
Sawlogs	364,858	351,371	13,487	—	—	351,371
Pulpwood	49,086	49,061	25	—	—	49,061
Other industrial	869	859	—	—	—	869
Total	414,813	401,301	13,512	—	—	401,301
Fuelwood	31,550	5,602	25,948	— ²	—	5,602
Logging residue	—	—	—	—	—	10,072
Total	446,363	406,903	39,460	—	—	416,975

¹Sawlogs, pulpwood, and other industrial volumes (McLain 1988b). Fuelwood volume (McLain 1988a).

²No board feet in other sources.

³Noninventory product volume factor for Arizona, 1985, is zero.

⁴Fuelwood originally reported in cords. Cords converted to cubic feet at rate of 78.6 ft³ per cord (standard conversion rate used in Arizona and New Mexico by the USDA Forest Service).

⁵Residue factors applied to sawlogs, pulpwood, and other industrial. Not applied to fuelwood.

⁶Fuelwood conversion—from logging residue study for all products: 1 ft³ = 6.037 bd ft (Scribner).

logging went into fuelwood (hence, no logging residue), and the fuelwood volume probably contained noninventory volume (magnitude unknown). For lack of anything else, we used the noninventory volume factors, which for Arizona equaled zero, developed from data collected on sawlog and other roundwood harvesting operations. The reader may wish to assume some other factor and apply it to fuelwood.

Use of Factors

The following illustrates the applications of the factors (table 2) to obtain a detailed analysis of noninventory product volume and the components of growing-stock removals (M cubic feet; table 3).

Estimate of growing-stock removals:

From products:

Live product volume x inventory product volume factor +	
Live fuelwood volume x inventory product volume factor	= Total growing-stock removals from products (TGSRP)

From logging residue:

Live product volume x logging residue factor +	
Dead product volume x non-product tree residue factor	= Total growing-stock removals from logging residues (TGSRLR)

Total removals from growing-stock = TGSRP + TGSRLR

or:

From products:

61,524 x 1	=	61,524
856 x 1	=	856

Total growing-stock removals from products (TGSRP) = 62,380

From logging residue:

61,524 x 0.071	=	4,368
2,087 x 0.016	=	33

Total growing-stock removals from logging residue (TGSRLR) = 4,401

Total removals from growing stock = 66,781

Estimate of noninventory product volume harvested:

Live product volume x noninventory product volume factor +	
Live fuelwood volume x noninventory product volume factor	=

Noninventory product volume harvested

61,524 x 0	=	0
856 x 0	=	0

Noninventory product volume harvested = 0

Alternative

To estimate total removals only, the following procedure could be used:

From products and logging residue (live sawlog, pulpwood, and other)

Live product volume x removals factor +

From logging residue (dead sawlog, pulpwood, and other)

Dead product volume x non-product tree residue factor +

From products (live fuelwood)

Live fuelwood volume x inventory product volume factor	= Growing-stock removals
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or:

From products and logging residue

61,524 x 1.071	=	65,892
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From logging residue

2,087 x 0.016	=	33
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From products

856 x 1	=	856
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Growing-stock removals = 63,781

Product Volume From Other Sources

Estimates of product volume cut from nonforest land and nontimber species, labeled "Other sources" in table 3, were obtained in the same manner as the salvable dead estimates. They came directly from the wood processors and fuelwood harvesters, not by application of factors to reported product volumes. Table 3 shows that fuelwood was the only product derived in any measurable volume from other sources.

Discussion of Factors

The growing-stock (cubic) removals factor exceeds 1 (table 2). This means that residue exceeded noninventory product volume. This is easily confirmed by comparing the residue factor with the noninventory product volume factor. In most instances, the top logs were bucked short of (below) a 4-inch top diameter outside bark (d.o.b.), often at 8 or 7 inches, or even, less frequently, at 6 inches d.o.b. The wood in the upper stems between the 8-, 7-, or 6-inch top d.o.b. and the 4-inch top d.o.b. is left in the woods as residue. This residue is a removal from inventory, not reflected in product volume.

The sawtimber removals factor also exceeds 1. This is due to harvesting sawtimber size trees or, conversely, not harvesting poletimber size trees. Had there been a significant harvest of poletimber size trees, there would have been board-foot product volume from those trees without a corresponding board-foot volume removed from the sawtimber inventory. Because the harvest comprised sawtimber size trees, all of the board-foot product volume was sawtimber removals. Additional sawtimber removals were logging residue, mostly tops left in the woods due to bucking the top log at diameters exceeding 7 inches d.o.b., and cutouts due to breakage of logs in the product tree resulting from felling.

Table 4 exhibits the Arizona removals factors from data collected in 1968 (Setzer and other 1970) compared to that collected in 1985. Current factors are 0.051 and 0.026 less than those of 1968, indicating less residue now than then.

LOGGING RESIDUE VOLUME IN PIECES 6 FEET AND LONGER

Table 5 contains the cubic volume of product tree residue in sound pieces ≥ 6 feet in length to a 4-inch top, the factors used to derive the volume estimates, and the proportion of product trees that produced residue ≥ 6 feet in length to a 4-inch top. The factors were derived from the logging utilization data by dividing the product tree residue volume in pieces ≥ 6 feet in length to a 4-inch top by the product volume from live trees. The factors are merely the residue volume expressed as a proportion of product volume. Multiplying the factors by the product volume from live timber trees reported by wood processors produces an estimate of residue volume in sound pieces ≥ 6 feet. Additional residue volume in pieces 6 feet and longer is often available from nonproduct trees damaged or killed by felling or skidding. The proportion of trees measured that produced residue in pieces 6 feet and longer may be indicative of the degree of utilization. The lower the proportion, the higher the utilization.

DIAMETER CLASS DISTRIBUTION OF TREES HARVESTED OR DAMAGED

Information on the number of growing-stock trees harvested or destroyed (and, therefore, removed from the inventory) in each diameter class and their associated volumes is useful for computing diameter class cutting rates, which in turn are useful for projecting residual inventory, growth, and yield. Logging utilization data provide an estimate of the distribution of trees removed in relation to the volume of logs harvested. Table 6 presents the total number and volume of growing-stock trees (product and nonproduct trees) removed per thousand cubic feet of product volume (excluding fuelwood) from live trees. These diameter distributions, which are statewide averages, may be applied to reported harvest volumes to determine removals by diameter class or be compared to previous years to determine change.

Table 4—Removal factors by Forest Survey standards to estimate total net removals from inventory due to logging, Arizona, 1985 compared to factors computed in 1968

Factor	1968 ¹	1985	Difference
Growing-stock removals (cubic)	1.122	1.071	(-0.051)
Sawtimber removals (bd ft)	1.051	1.025	(-0.026)

¹Setzer and others 1970.

Table 5—Volume of, proportion of harvest volume (factor) in, and proportion of product trees containing logging residue to a 4-inch top in pieces 6 feet and longer, Arizona, 1984

Residue volume in pieces 6 feet and longer (MCF)	Factor ¹ for residue volume in pieces 6 feet and longer	Proportion of product trees producing residue volume in pieces 6 feet and longer
2,584	0.042	0.802

¹Apply to product volume.

Table 6—Diameter at breast height (d.b.h.) class distribution of the number and volume of growing-stock trees removed from inventory through harvesting per MCF of net product volume, Arizona, 1985—the number of trees removed in 1968 provided for comparison. The 1968 volume by d.b.h. class is unavailable

D.b.h. class	Number of growing-stock trees		Volume of growing-stock trees in cubic feet, 1985
	1968 ¹	1985	
2	47.62	3.05	—
4	27.70	3.72	0.03
6	6.59	1.73	3.37
8	2.22	.67	3.75
10	1.18	.38	3.11
12	.56	.93	16.26
14	1.14	1.32	32.44
16	1.70	1.28	42.32
18	1.91	1.86	82.96
20	2.22	1.67	104.59
22	.59	1.80	147.19
24	1.39	1.19	118.93
26	.80	1.22	153.58
28	.59	.70	104.75
30+	1.63	1.25	257.88
All classes	97.85	22.78	1,071.16

¹Setzer and others 1970.

PRODUCT VOLUME CONVERSIONS

The conversion factors in table 7 were estimated from logging utilization data derived from measurements obtained on the sawlog and multiproduct harvesting operations composing the sample for Arizona. They are thus statewide averages, reflecting average conversion for the harvest of the product mix encountered on the samples measured. Caution is recommended in applying these factors to State subdivisions or to harvests of a narrow range of products of small size, such as posts or fuelwood, or sawlogs of exceptionally large diameters (see table 6).

Table 7—Product volume conversion factors for Arizona

1 cubic foot equals	6.0370	board feet (Scribner)
1 cubic foot equals	6.5441	board feet (International 1/4-inch)
1 board foot equals (Scribner)	1.0840	board feet (International 1/4-inch)

RELIABILITY OF ESTIMATES

The computation of the standard error of the various residues and utilization percentages employs the formula for the standard error of a ratio (Wilson 1965), which may be stated:

$$Sr = \sqrt{\frac{\bar{r}^2}{n} \left[\frac{\sum (y_i - \bar{y})^2}{(n-1)\bar{y}^2} + \frac{\sum (x_i - \bar{x})^2}{(n-1)\bar{x}^2} - \frac{2\sum (x_i - \bar{x})(y_i - \bar{y})}{(n-1)\bar{y}\bar{x}} \right]}$$

where

y = logging residues measured on an operation
(net volume)

x = timber products measured on an operation
(net volume)

$\bar{r} = \frac{\sum y}{\sum x}$ = logging residues ratio

n = total number of operations sampled

$\bar{y} = \frac{\sum y}{n}$

$\bar{x} = \frac{\sum x}{n}$

Sy^2 = variance for $y = \frac{\sum (y_i - \bar{y})^2}{n-1}$

Sx^2 = variance for $x = \frac{\sum (x_i - \bar{x})^2}{n-1}$

$Cov.(yx)$ = covariance of y and $x = \frac{\sum (y_i - \bar{y})(x_i - \bar{x})}{n-1}$

Sr^2 = variance for $r = \frac{\bar{r}^2}{n} \left[\frac{Sy^2}{\bar{y}^2} + \frac{Sx^2}{\bar{x}^2} - \frac{2 Cov.(yx)}{\bar{y}\bar{x}} \right]$

$Sr = \sqrt{Sr^2}$ = standard error of the ratio ($\bar{r}$)

$SE(\%) = \frac{Sr}{\bar{r}} \times 100$ = standard error of the ratio as a percentage of the ratio.

Table 8 gives the achieved standard errors of the logging residue volume/product volume ratios and the standard errors as percentages of the ratios.

Table 8—Achieved standard errors of the logging residue volume/product volume ratios and the standard errors as percentages of the ratios

	Sr	$SE(\%)$
Cubic foot	0.0111	15.59
Board foot, Scribner	.0045	19.17
Board foot, International 1/4-inch	.0049	18.12

TERMINOLOGY

Cubic-foot/board-foot conversions—The cubic-foot volume in product logs compared to the board-foot volume in the same logs.

Cull tree—A live timber species tree that is less than one-third sound or does not contain a merchantable 8-foot bolt (poletimber size tree) or a 12-foot sawlog in the butt log (sawtimber size tree).

Dead product volume—Same as salvageable dead volume. The cubic volume in dead poletimber-size and sawtimber-size trees of timber species from a 1-foot stump to a minimum 4-inch top d.o.b.. The board-foot volume in dead sawtimber-size trees of timber species between a 1-foot-high stump and a 7-inch d.o.b. top (softwoods) or 9-inch d.o.b. top (hardwoods).

Forest lands—Lands at least 10 percent stocked by forest trees of any size, including lands that formerly had such tree cover and that will be naturally or artificially regenerated. The minimum area for classification of forest land is 1 acre. Roadside, streamside, and shelterbelt strips of timber must have a crown width at least 120 feet wide to qualify as forest land. Unimproved roads and trails, streams, and clearings in forest areas are classified as forest if less than 120 feet wide.

Forest trees—Woody plants having a well-developed stem or stems, usually more than 12 feet in height at maturity, with a generally well-defined crown.

Growing-stock product volume—The growing-stock volume in timber products such as sawlogs, posts, poles, pulpwood, fuelwood, and house logs.

Growing-stock removals (in this publication)—The growing-stock volume removed from inventory by harvesting. Consists of logging residue and the growing-stock volume of products.

Growing-stock trees (in this publication)—Live sawtimber trees and poletimber trees meeting specified standards of quality and vigor; excludes cull trees.

Growing-stock volume—Net cubic-foot volume in live poletimber-size and sawtimber-size growing-stock trees from a 1-foot stump to a minimum 4-inch top (of central stem) outside bark or to the point where the central stem breaks into limbs.

Industrial wood products—All timber products except fuelwood.

Inventory product volume—The growing-stock or sawtimber volume in timber products.

Live product volume—Product volume minus salvable dead and other sources.

Logging residue—The unused growing-stock or sawtimber volume of trees cut or killed by logging and left in the woods.

M—Thousand.

Mbf—Thousand board feet.

MCF—Thousand cubic feet.

MM—Million.

Noninventory product volume—The cubic volume of timber products that came from the upper stems (beyond the 4-inch top d.o.b.) or below the 1-foot-high stumps of growing-stock product trees; the board-foot volume in timber products that came from poletimber trees and below the 1-foot-high stump of sawtimber trees; the product volume of cull trees.

Non-National Forest lands—Lands not administered by the Forest Service, U.S. Department of Agriculture.

Nonproduct tree residue—The growing-stock or sawtimber volume of nonproduct trees cut, killed, or damaged while felling or skidding product trees. This volume is left in the woods. It is a component of slash.

Nonproduct trees—Those trees cut, killed, knocked down, or destroyed due to felling and skidding the product trees.

Nontimber tree—Other than timber species.

Other sources—Product volume from nontimber species (such as juniper and, in the West, oak) and trees harvested on nonforest land (such as urban streets, orchards, and windbreaks).

Poletimber tree—A live tree of timber species, at least 5 inches diameter at breast height (d.b.h.) but smaller than sawtimber size, containing at least one 8-foot bolt, and more than one-third sound.

Primary wood processors—Mills, plants, and yards receiving logs for processing into such products as studs, boards, lumber, fiberboard, plywood, utility and building poles, house logs, excelsior, pulp and paper, pulp chips, mine timbers, railroad ties, pilings, hop stakes, grape stakes, barrel staves, siding, paneling, and shakes. Primary wood processors include sawmills, fiberboard mills, plywood plants, house log plants, post and pole yards, post and pole treating plants, excelsior manufacturing plants, and pulp and paper mills.

Product tree residue—The unused growing-stock or sawtimber volume of product trees that is left in the woods.

Product trees—Those trees selected for harvest. Trees felled for products such as sawlogs, posts, poles, pulpwood, fuelwood, or house logs.

Product volume—The cubic-foot or board-foot volume in timber products such as sawlogs, posts, poles, pulpwood, fuelwood, and house logs. Product volume comprises volume from salvable dead trees, other sources, and the noninventory and growing-stock (or sawtimber) volume from growing-stock trees.

Removals (in this publication)—The growing-stock and sawtimber volume removed from the inventory by harvesting. Consists of logging residue and the growing-stock and sawtimber volume of products.

Residual inventory (in this publication)—The growing-stock and sawtimber volume remaining after the inventory is reduced through removals due to harvest.

Salvable dead trees—Standing or down dead trees of timber species that are merchantable by regional standards.

Salvable dead volume—The cubic volume in dead poletimber-size and sawtimber-size trees of timber species from a 1-foot stump to a minimum 4-inch top d.o.b. The board-foot volume in dead sawtimber-size trees of timber species between a 1-foot-high stump and a 7-inch d.o.b. top (softwoods) or 9-inch d.o.b. top (hardwoods).

Sawlog portion—That part of the bole of sawtimber trees between a 1-foot stump and the sawlog top.

Sawlog top—The portion on the bole of sawtimber trees above which a sawlog cannot be produced. The minimum sawlog top is 7 inches d.o.b. for softwoods and 9 inches d.o.b. for hardwoods.

Sawtimber product volume—The sawtimber volume in timber products.

Sawtimber removals (in this publication)—The sawtimber volume removed from inventory by harvesting. Consists of logging residue and the sawtimber volume of products.

Sawtimber tree—A live tree of timber species meeting regional size and defect specifications. A softwood tree must be at least 9 inches d.b.h. and a hardwood tree 11 inches d.b.h. The tree must contain at least a 12-foot sawlog in the butt log and be more than one-third sound.

Sawtimber volume—Net volume in board feet of the sawlog portion of live sawtimber trees.

Slash—The wood volume cut or killed as a result of logging and left in the woods (not hauled out as timber products). Slash consists of logging residue (growing-stock and sawtimber volume) and noninventory volume (such as tree tops, limbs, cull trees, dead trees, and nontimber trees).

Timberland—Forest land where timber species make up at least 10 percent stocking.

Timber products—Roundwood products such as sawlogs, posts, poles, pulpwood, fuelwood, veneer logs, and house logs.

Timber removals—Same as "Removals."

Timber species—Trees traditionally used for industrial wood products. In the Rocky Mountains, these include only two hardwoods, aspen and cottonwood, and all softwood species except pinyon and juniper.

Total removals (associated with harvesting)—Comprises the growing-stock (or sawtimber) volume contained in products, the product tree logging residue, and the nonproduct tree logging residue.

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Reports results of a study made on timber harvesting operations in Arizona to derive
factors used to estimate logging residue, growing stock and sawtimber removals, diame-
ter class distributions of harvests, and board-foot/cubic-foot conversions.

KEYWORDS: timber removals, growing-stock removals, sawtimber removals, cubic/
board-foot conversions, logging residue

INTERMOUNTAIN RESEARCH STATION

The Intermountain Research Station provides scientific knowledge and technology to improve management, protection, and use of the forests and rangelands of the Intermountain West. Research is designed to meet the needs of National Forest managers, Federal and State agencies, industry, academic institutions, public and private organizations, and individuals. Results of research are made available through publications, symposia, workshops, training sessions, and personal contacts.

The Intermountain Research Station territory includes Montana, Idaho, Utah, Nevada, and western Wyoming. Eighty-five percent of the lands in the Station area, about 231 million acres, are classified as forest or rangeland. They include grasslands, deserts, shrublands, alpine areas, and forests. They provide fiber for forest industries, minerals and fossil fuels for energy and industrial development, water for domestic and industrial consumption, forage for livestock and wildlife, and recreation opportunities for millions of visitors.

Several Station units conduct research in additional western States, or have missions that are national or international in scope.

Station laboratories are located in:

Boise, Idaho

Bozeman, Montana (in cooperation with Montana State University)

Logan, Utah (in cooperation with Utah State University)

Missoula, Montana (in cooperation with the University of Montana)

Moscow, Idaho (in cooperation with the University of Idaho)

Ogden, Utah

Provo, Utah (in cooperation with Brigham Young University)

Reno, Nevada (in cooperation with the University of Nevada)

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